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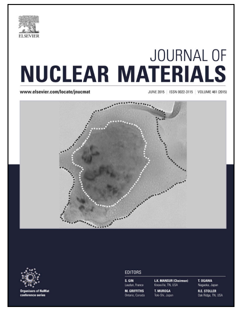

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Finite Element analysis of ion transport in Solid State Nuclear Waste Form Materials

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Abstract

Release of nuclear species from spent fuel ceramic waste form storage depends on the individual constituent properties as well as their internal morphology, heterogeneity and boundary conditions. Predicting the release rate is essential for designing a ceramic waste form, which is capable of effectively storing the spent fuel without contaminating the surrounding environment for a longer period of time. To predict the release rate, in the present work a conformal finite element model is developed based on the Nernst Planck Equation. The equation describes charged species transport through different media by convection, diffusion, or migration. And the transport can be driven by chemical / electrical potentials or velocity fields. The model calculates species flux in the waste form with different diffusion coefficient for each species in each constituent phase. In the work reported, a 2D approach is taken to investigate the contributions of different basic parameters in a waste form design, i.e., volume fraction, phase dispersion, phase surface area variation, phase diffusion co-efficient, boundary concentration etc. The analytical approach with preliminary results is discussed. The method is postulated to be a foundation for conformal analysis based design of heterogeneous waste form materials.

1. Introduction

Radioactive waste streams resulting from legacy weapons production as well as advanced commercial fuel cycles[i], present researchers with the challenge to manage the waste in an efficient and safe manner. An efficient system must have the capability to contain a radioactive material within itself and limit the release of the waste material in the surrounding environment to an allowable release rate. Among different waste form materials, SYNROC-C is a titanate based ceramic composed of four different targeted phases – zirconolite, hollandite, perovskite, and pyrochlore[ii]. Different Separation processes isolate several important radionuclides that need